California Building Energy Benchmarking: Current and Future Directions

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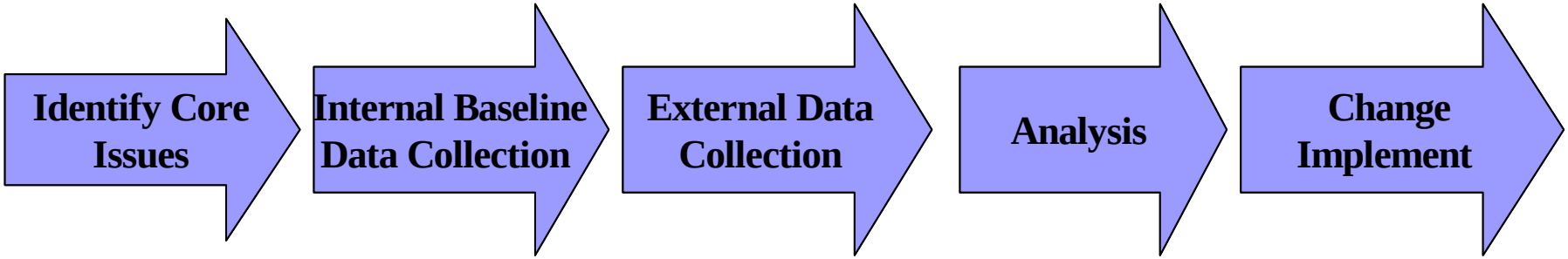
Presentation Overview

- Presentation Overview
- Benchmarking Basics
- California Benchmarking Tool: Cal-Arch
- California and National Benchmarking
- Future Tools using New CEUS
- Summary

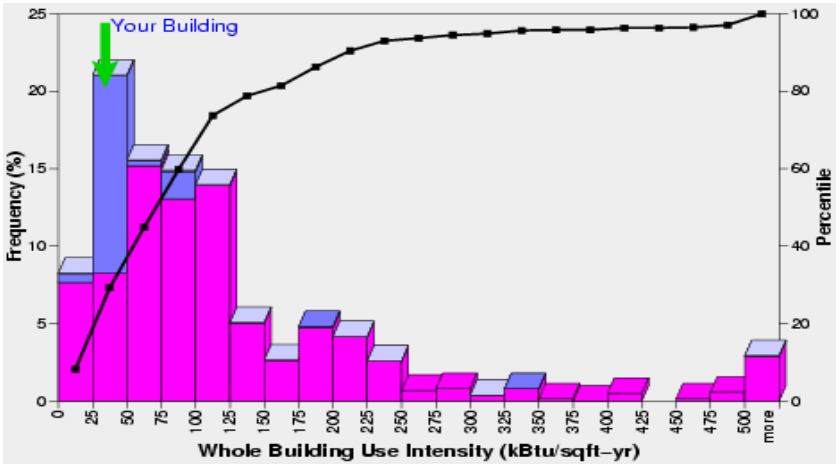
Benchmarking Basics: Why Benchmark?

- Determine how well a building is performing
- Compare energy consumption to similar buildings
- Set targets for improved performance
- Facilitate assessment of property value
- Gain recognition for exemplary achievement
- Identify actions for energy savings



California Benchmarking Tool: Cal-Arch

- Simple online tool for benchmarking energy use in California commercial buildings
  - EUI = energy use use intensity (energy/square foot-year)
- EUIs represent actual energy use
  - No adjustments or correction factors, site or source energy
- Provides energy use for similar buildings, as determined by type, size, and climate zone
- http://poet.lbl.gov/cal-arch

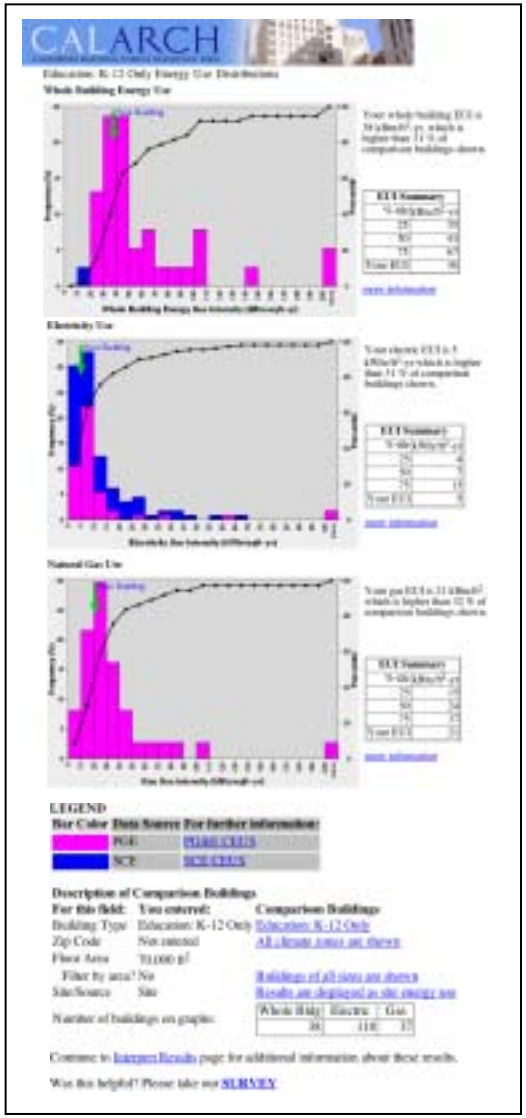


Cal-Arch Data Sources: CEUS

California Commercial End Use Survey

- Conducted by utilities to support forecasting & program design
- Currently using 1995 PG&E, 1992 SCE, 1995 SCE surveys (~2000 sites total)
- Extremely detailed
  - Mechanical, structural, end uses characteristics
- Limited use of survey: Zip code/climate zone, type, size, energy use (fuels by end-use, billing data)
- New CEUS – 2800 audits with energy data and DOE-2 models, and energy efficiency measures
- Additional LBNL research to collect schools data with CHPS, utilities, and CEC

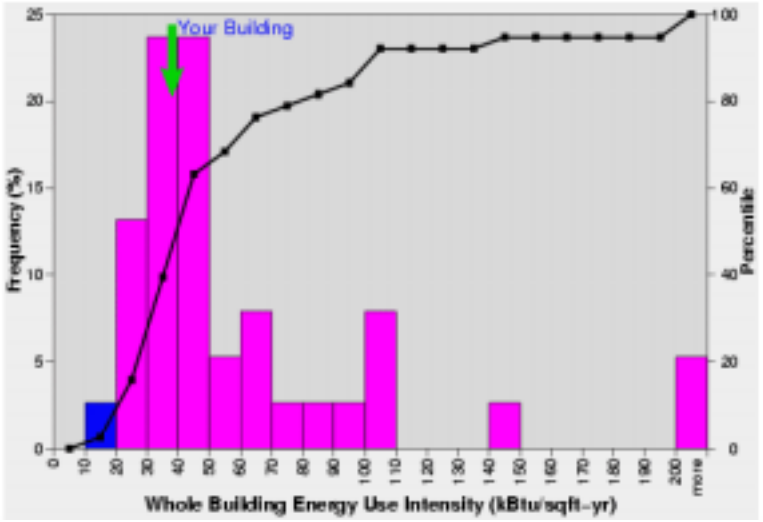
Cal-Arch Results



CALARCH
CALIFORNIA BUILDING ENERGY REFERENCE TOOL

Education: K-12 Only Energy Use Distributions

Whole Building Energy Use



Your whole building EUI is 38 kBtu/ft^2-yr, which is higher than 31 % of comparison buildings shown.

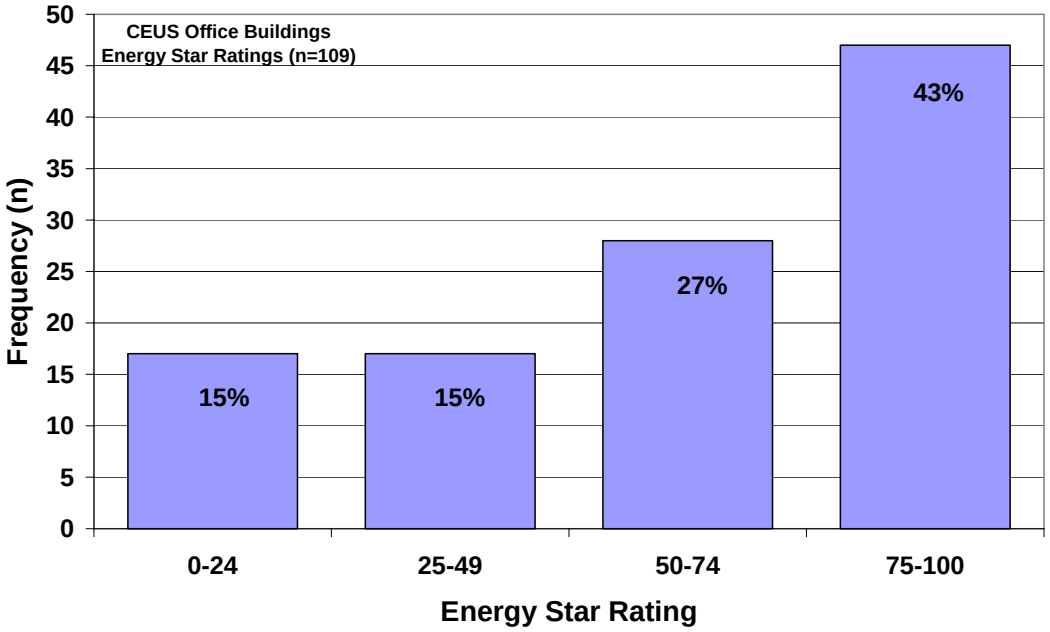
EUI Summary	
%-tile	kBtu/ft^2-yr
25	35
50	43
75	67
Your EUI	38

more information

- **Shows your building's energy use compared to similar buildings in CEUS**
  - **Electric, Gas and Whole Building EUI values**
  - **Percentage of buildings with lower EUIs**

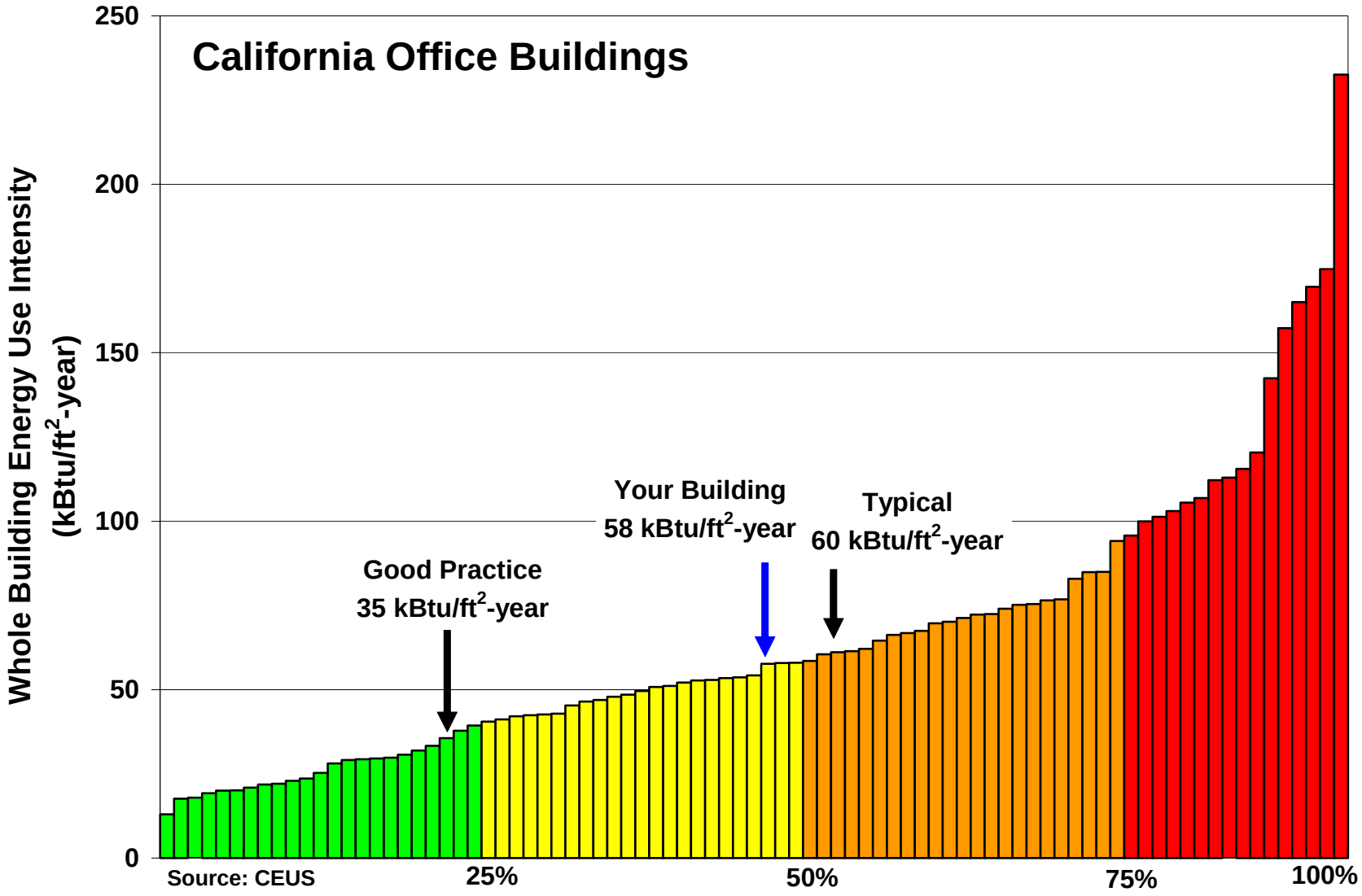
California and National Benchmarking: Consistent Results

- California buildings tend to have high Energy Star Scores
- CEUS analysis used to improve Energy Star methodology



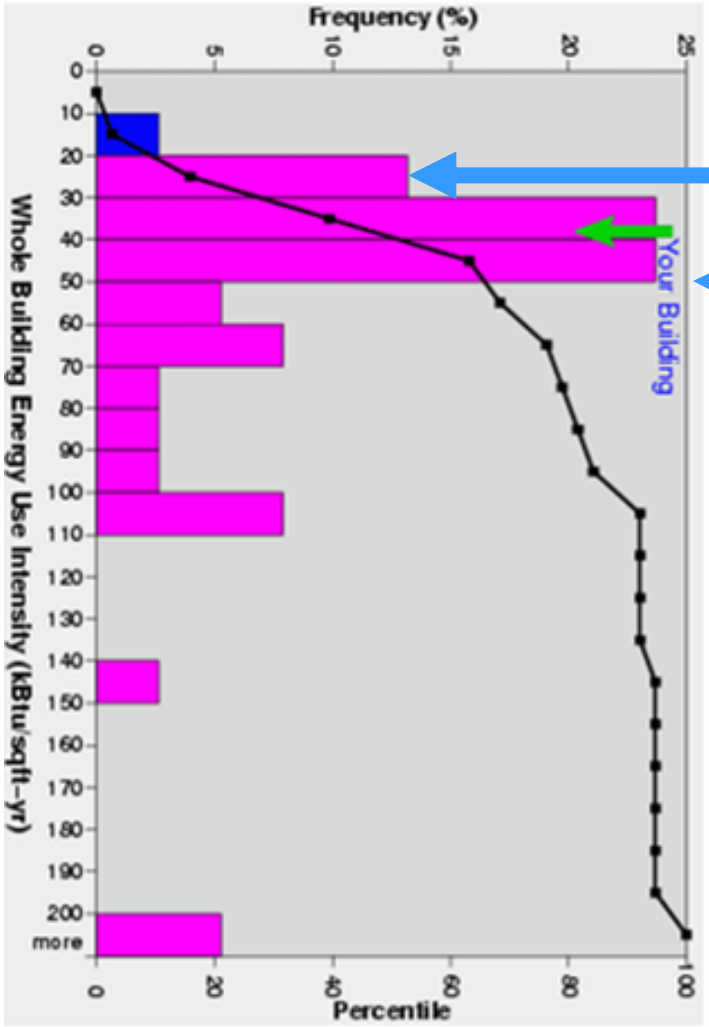
3 CEUS Office Buildings North Coast Climate zone	Building A	Building B	Building C
Floor Area (ft^2)	30,000	500,000	300,000
Whole Building (EUI)	29	52	143
Energy Star Rating	98	82	23
Percent of Cal-Arch office buildings with greater EUI			
North Coast Climate Zone	79%	54%	10%

Future CEUS-Based Tools
Numerous Ways to Display Data



Compare to Typical and Good Practice

- Agricultural
- Education
- Education – K-12 only
- Enclosed Shopping/Mall
- Food Sales
- Food Services (Restaurant)
- Health Care (Inpatient)
- Health Care (Outpatient)
- Industrial Processing



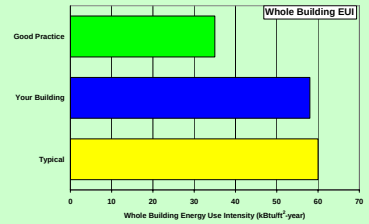
Good Practice

Typical

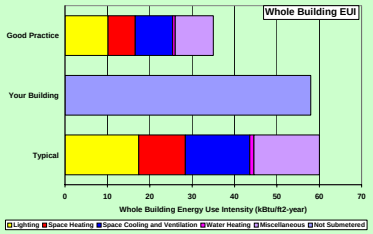
- Lodging (Hotel/Motel/Dorm)
- Nursing Home
- Office/Professional
- Public Assembly
- Public Order & Safety
- Religious Worship
- Retail (except mall)
- Service (except food)
- Warehouse (non-refrigerated)
- Warehouse (refrigerated)

Action-Oriented Benchmarking: Benchmarking to Retrofit Options

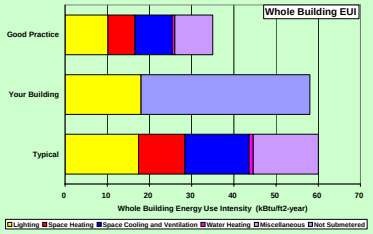
1. Basic Energy Use Intensity (EUI)



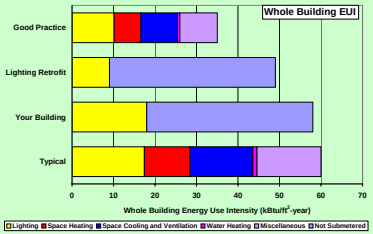
2. Default End Uses



3. Calculate your building's end uses

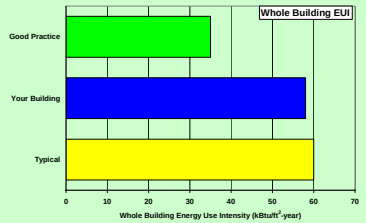


4. Retrofit Options & Results

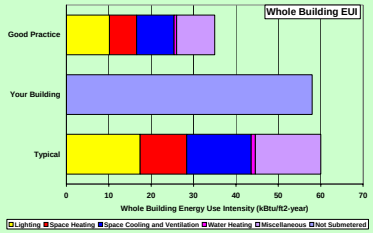


Layered Approach from Simple to Detailed Information

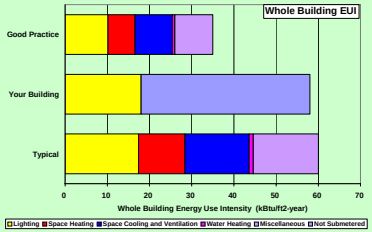
1. Basic Energy Use Intensity (EUI)
   - Building Type
   - Climate Zone
   - Floor Area
   - Energy Use



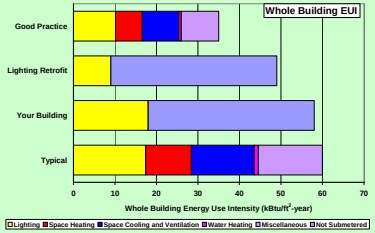
2. Default End Uses
   - Specify your building's end-uses



3. Calculate your building's end uses
   - Detailed end-use characteristics

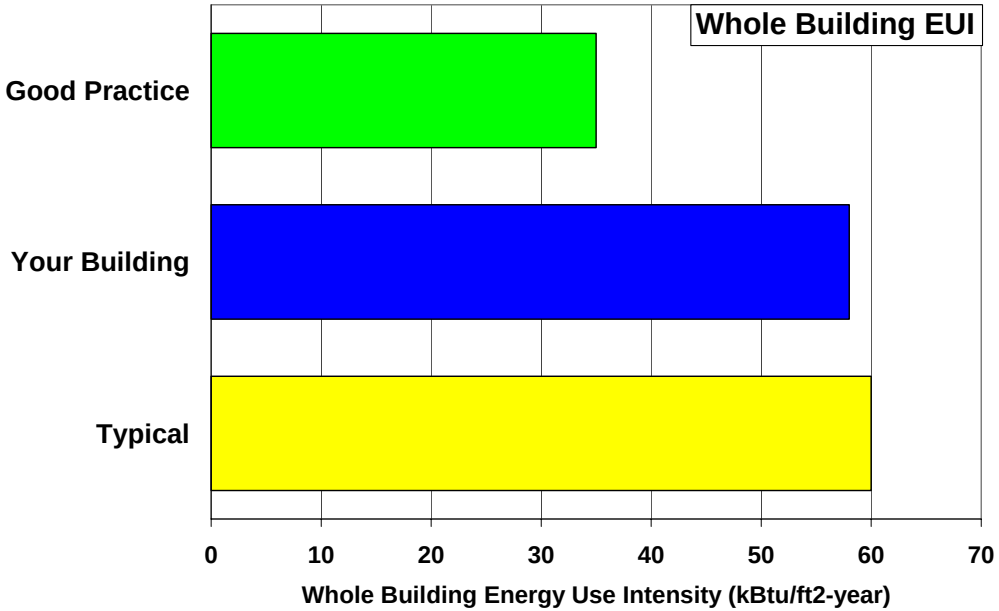


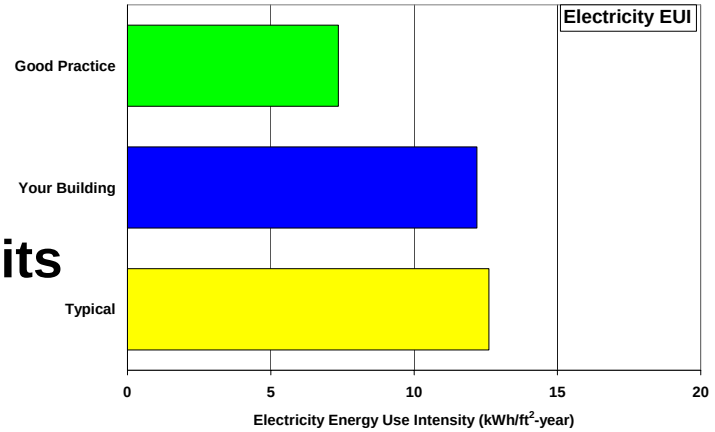
4. Retrofit Options & Results
   - Select retrofit options by end use

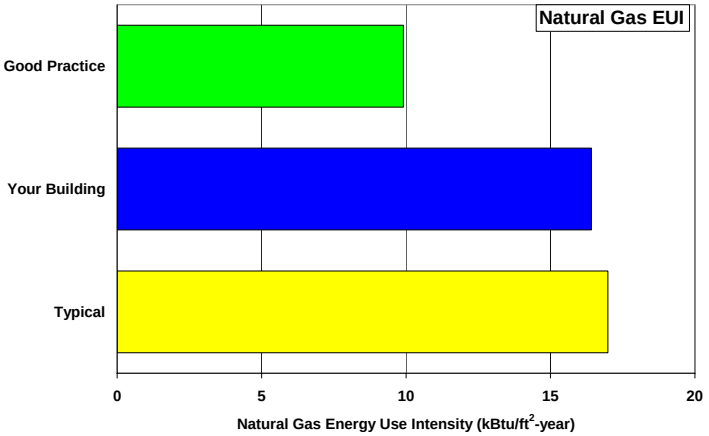


1. Energy Use Intensities

1. **Compare your building's energy use intensities (EUIs) to typical and good practice cases:**
   - **By type and climate**
   - **By fuel (electricity and natural gas) or whole building**
   - **kBtu/ft^2-yr site or source energy units**



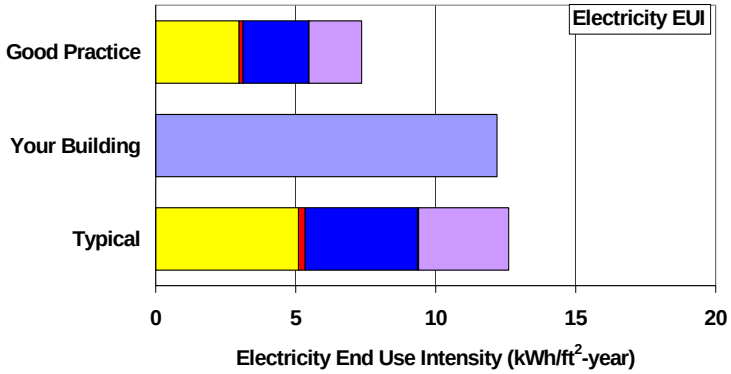


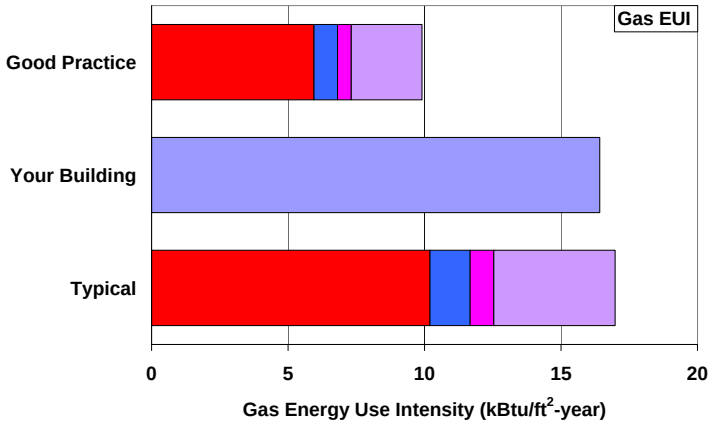


2. Default End-Uses

2. Review default end-use distributions for typical and good practice (UK/EU approach):

- By fuel (electricity and natural gas)
- Specify your building's end uses:
  - Lighting
  - Space Heating and Cooling
    - Heating
    - Cooling
    - Fans and Ventilation
  - Water Heating
  - Miscellaneous
    - Office Equipment
    - Refrigeration
    - Cooking
    - Outdoor Lighting
    - Other Misc.
  - ? Other end uses?





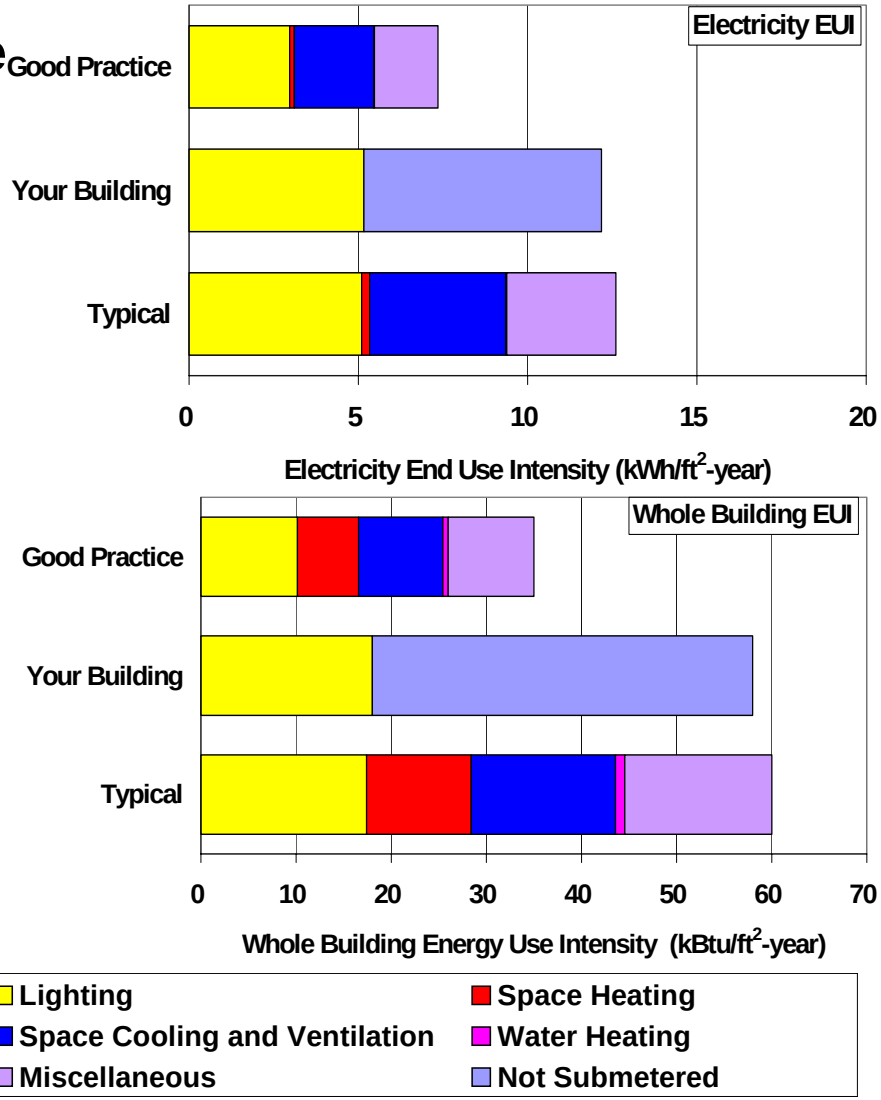
Lighting
Space Heating
Space Cooling and Ventilation
Water Heating
Miscellaneous
Not Submetered

End-Use Breakdowns from CEC 1998 Energy Baseline

3. Calculate End-Use Energy – Lighting

3. Use simplified methods to estimate end-use consumption:

Lighting	Base Case
Lighting power, W (watts/ft^2)	1.5
Lighting control factor, C_o (no occupancy sensors)	1
Diversity Factor, D_f (actual % of lighting power used)	0.9
Main shift occupied hours, H_o (hours/week)	50
Percent of lighting load during off hours, L_u	20%
Estimated Lighting EUI (kWh/ft^2-year)	**5.2**
Estimated Lighting EUI (kBtu/ft^2-year)	**18**



Lighting EUI (kBtu/ft^2-year) = (52 weeks/year) x (H_o x C_o + (1-Ho)xL_u) x D_f x W) x (kW/1000W) x (3.412 kBtu/kW)

4. Select Retrofits – Indoor Lighting

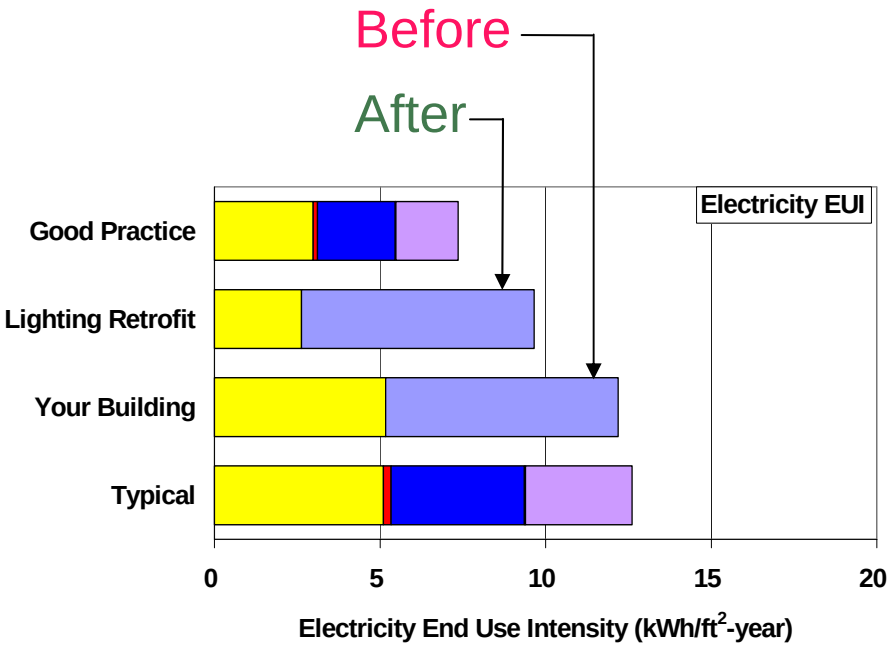
Possible Lighting Retrofits in CEUS (➨):

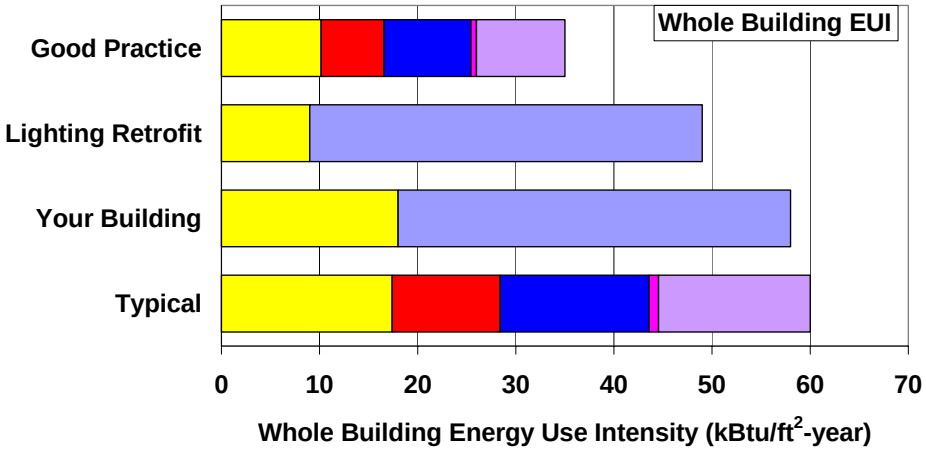
- ❑ Lamp Replacement (T-12 to T-8) (consider T24 upgrade)
- ❑ Hi-efficiency Ballast
- ❑ Incandescent to CFL conversion
- ❑ Occupancy Sensors (consider T24 upgrade)
- ❑ Lighting Controls
- ❑ Rezoning

Lighting Retrofit: lamps, occupancy sensors, rezoning	Base Case	Retrofit
Lighting power, W (watts/ft^2)	1.5	1.2
Lighting control factor, C_o	1	0.7
Diversity Factor, D_f (actual % of lighting power used)	0.9	0.9
Main shift occupied hours, H_o (hours/week)	50	50
Percent of lighting load during off hours, L_u	20%	10%
Estimated Lighting EUI (kWh/ft^2-year)	**5.2**	**2.6**
Estimated Lighting EUI (kBtu/ft^2-year)	**18**	**9**

4. Evaluate Retrofits

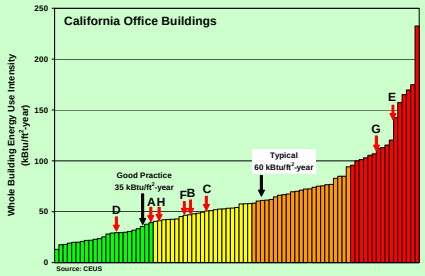
- Proposed retrofit reduces EUI by ~3 kWh/ft^2-year (9 kBtu/ft^2-year)
- Add payback estimate.





Basic Benchmarking: 3 User Interface Options

- One building at a time



- Batch Mode – submit spreadsheet

XML

- Integrated with web energy services -

  Interoperate with Energy Information Systems e.g. Interact

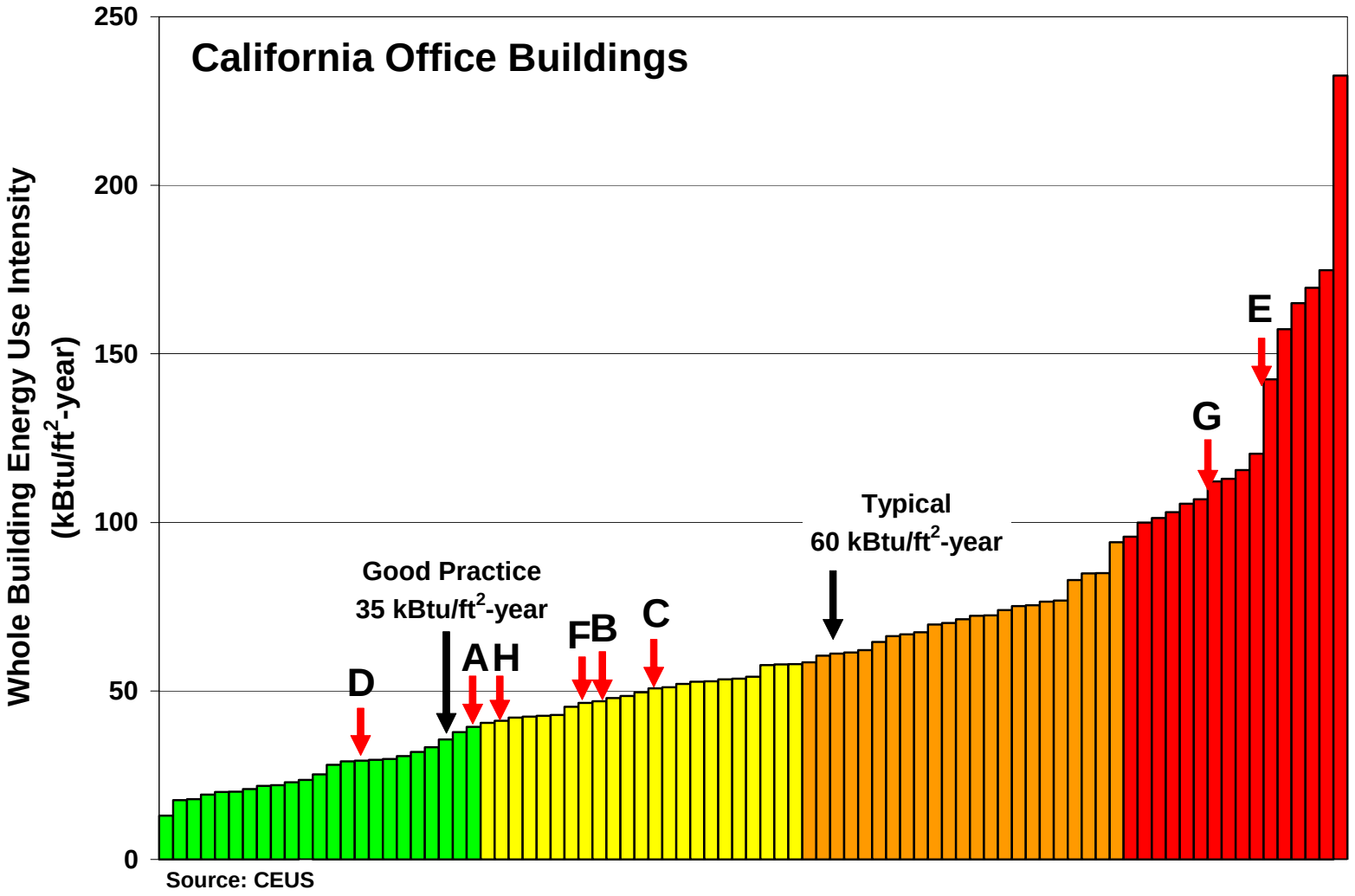
Batch Mode Option

Spreadsheet Input Screen

California Benchmarking Tool - Building Inputs					
Facility	Building Type	Climate Zone	Floor Area (ft2)	Annual Electricity Consumption (kWh)	Annual Natural Gas Consumption (Therms)
A	Office Building	North Coastal	100,000	2,808,000	1,092,000
B	Office Building	South Coastal	30,000	1,015,200	394,800
C	Office Building	Inland	250,000	9,180,000	3,570,000
D	Office Building	North Coastal	450,000	9,720,000	3,780,000
E	Office Building	Mountain / Desert	35,000	3,528,000	1,372,000
F	Office Building	Inland	150,000	5,184,000	2,016,000
G	Office Building	Mountain / Desert	1,000,000	78,480,000	30,520,000
H	Office Building	South Coastal	750,000	22,680,000	8,820,000

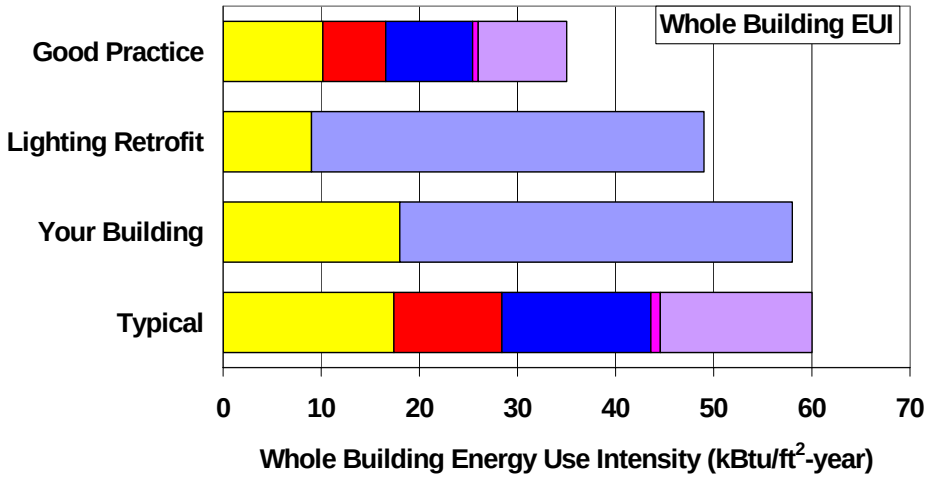
Batch Mode Option

Results



Summary

- California & national tools good starting point for benchmarking; development has been coordinated and mutually beneficial
- New data & models provide opportunity to improve tools
- Web-based, batch mode, and integration with Energy Information Systems
- Future tools – Action Oriented, Title 24 Baseline



Further Information

- **Contact:**
  - MAPiette@lbl.gov (510) 486-6286
  - NEMatson@lbl.gov (510) 486-7328
- **Web Site:**
  - http://poet.lbl.gov/cal-arch
  - Additional benchmarking tools:
    - http://poet.lbl.gov/cal-arch/links/
- High Performance Commercial Building Systems (CEC PIER funded)
  - http://buildings.lbl.gov/hpcbs
- Cal-Arch Papers:
  - http://buildings.lbl.gov/hpcbs/Pubs.html